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COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS AND ON THE GLOBALLY HARMONIZED SYSTEM OF CLASSIFICATION AND LABELLING OF CHEMICALS

Sub-Committee of Experts on the Transport of Dangerous Goods

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LISTING, CLASSIFICATION AND PACKING

Fuel cell systems and fuel cartridges containing borohydrides

Comments on documents ST/SG/AC.10/C.3/2005/16 and -/32

Transmitted by the expert from France

Introduction

1. The expert from France would like to thank the experts from Japan and from the United States of America for raising the issue of fuel cells. Nevertheless, after having checked different systems that industry wants to put on the market, it appears that a single entry under class 2 might not be the most appropriate way to deal with that issue, especially for fuel cells based on the use of borohydrides.

2. Therefore the expert from France would like to share the following information with the Sub-Committee and submit the annexed proposal.

3. As portable electronic devices continue to evolve, consideration is being given to the use of various types of fuel cell technologies to meet increasing power demands. One rapidly advancing fuel cell technology employs borohydrides as fuel. Since fuel cells function by combining hydrogen and oxygen to produce electricity, borohydrides are an ideal fuel in terms of available hydrogen density. Borohydride fuel cells also provide a number of safety and commercial advantages as compared to current battery technology, which make them particularly well suited for portable electronic applications.

4. Typically sodium borohydride is used as the fuel, but potassium borohydride may also be used. The fuel may either be in the form of a solid borohydride (including formulations) meeting the criteria for classification in Division 4.3, or in the form of liquid or solid formulations meeting the criteria for classification in Class 8. In the latter case, the formulations are “stabilized” (for example, in the case of liquid formulations by addition of an alkaline component, typically sodium hydroxide solution) so that hydrogen gas evolution is controlled. When the fuel is in a solid form, the system must also contain water which is necessary for the processing of the fuel within the system to produce the hydrogen with which the system generates electricity. The Annex II to this document provides further information on borohydride fuel cells, the fuels they employ, their manner of operation, and the management of risks posed by such systems.

5. For the last several years, a technical committee of the International Electrotechnical Commission (IEC) has developed a standard IEC/PAS 62282-6-1 Ed. 1. This standard applies to small (i.e., “easily carried by hand”) fuel cell power systems with outputs that do not exceed 60 Volts and 240 Watts. This standard addresses various types of fuel cells, including those using borohydrides as fuel, and prescribes a number of design and construction features to ensure the safety of these systems not only in transport, but also during use by consumers. Under the standard, the design of fuel cell systems, and cartridges used to supply fuel to the systems, must be qualified by performance of a series of tests, including, for example, vibration, altitude simulation, drop, and compression.

6. As the commercialization phase of borohydride fuel cell development approaches, there is a need to transport both borohydride fuel cell power systems, and cartridges containing fuel for these systems. However, neither the current provisions of the UN Model Regulation nor the proposals made in documents ST/SG/AC10/C3/2005/16 and 32 do provide suitable provisions for the transport of these articles containing borohydrides.

7. Although other borohydrides may be used, it has to be noted that the substances most commonly used are mentioned by name in the dangerous goods list (SODIUM BOROHYDRIDE UN 1426 cl 4.3 PG I,II or III and SODIUM BOROHYDRIDE AND SODIUM HYDROXYDE SOLUTION UN 3320 cl 8 PG II or III). Basically the fuel cell cartridges are small receptacles of very goods quality (due to conformity to IEC standards) containing those substances, assigning them to class 2 would not convey the right message for danger identification

8. Consequently, the text in annex I proposes the addition of two new entries - one in Division 4.3 and one in Class 8 - to address the transport of borohydride fuel cell power systems and fuel cartridges. Fuel systems and cartridges authorized for transport under the proposed entries would be limited to those covered by, and fully complying with, IEC/PAS 62282-6-1 Ed. 1. Packing and associated transport provisions are proposed which take account of the fact that the articles themselves would already be required to pass rigorous performance tests under the IEC standard.

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ANNEX I

Proposals

The following amendments to the UN Model Regulation are proposed:

a) Two new entries would be added to the Dangerous Goods List in Chapter 3.2 of the Model Regulation to read:

-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11
XXXX	FUEL CELL CONTAINING BOROHYDRIDE, SOLID or FUEL CELL CARTRIDGE CONTAINING BOROHYDRIDE, SOLID	4.3		I	3AA 3BB	NONE	P003	PP88		
		4.3		II	3AA 3BB	500 g	P003	PP88		
		4.3		III	3AA 3BB 223	1 kg	P003	PP88		
YYYY	FUEL CELL CONTAINING BOROHYDRIDE, STABILIZED or FUEL CELL CARTRIDGE CONTAINING BOROHYDRIDE, STABILIZED	8		II	3AA	1 L or 1 kg	P003	PP88		
		8		III	3AA 3CC 223	5 L or 5kg	P003 LP01	PP88		

b) Three new Special Provisions would be added in Chapter 3.3 of the Model Regulation to read:

"3AA This entry applies to small (i.e., easily carried by hand) fuel cell power systems with outputs that do not exceed 60 V and 240 W, that are fueled by sodium borohydride or potassium borohydride. Borohydride fuels may either be solids meeting the criteria for classification in Division 4.3 (UN XXXX), or liquid or solid formulations meeting the criteria for classification in Class 8 and stabilized to control evolution of hydrogen (UN YYYY), for example, in the case of liquid formulations, in solution with a stabilizer such as sodium or potassium hydroxide. The entry also applies to fuel cell cartridges that store fuel for discharge into these fuel cell power systems through a valve(s) that controls the discharge of fuel into the system. Fuel cell power systems and fuel cell cartridges shall be designed and constructed to prevent fuel from leaking under normal conditions of transport, and shall otherwise meet all applicable requirements of IEC/PAS 62282-6-1 Ed.1 ("Micro Fuel Cells - Safety")."

"3BB Irrespective of 4.1.1.6, fuel cell systems may contain water provided the design of the fuel cell system includes two independent means of preventing inadvertent uncontrolled mixing of water with the borohydride during transport, in accordance with the applicable requirements of IEC/PAS 62282-6-1 Ed. 1."

"3CC Sufficient stabilizer (e.g., sodium hydroxide solution in the case of liquid fuels) must be present to effectively stabilize the sodium borohydride so that the fuel does not meet the criteria for classification in Division 4.3 and to prevent any dangerous evolution of hydrogen under normal conditions of transport."

c) In Packing Instruction P003, Special Packing Provision "PP88" would be revised by adding "UN XXXX and UN YYYY" immediately following "UN 3473".

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ANNEX II

Information on Borohydride Fuel Cells and Borohydride Fuels

Background

As portable electronic devices continue to evolve, current battery technology is not keeping pace with increasing demands for power. As an alternative to conventional battery technologies, consumer electronics manufacturers are developing micro fuel cell technologies to power the next generation of modern devices. Micro fuel cells represent a completely new technology, based on fuels such as sodium borohydride and potassium borohydride to generate electrical power, rather than the alkaline, NiCd, NMH and lithium chemistry found in current primary and secondary batteries today.

Micro fuel cell developers are committed to designing and building systems that meet stringent safety standards that ensure that this technology is safe for consumers to use and transport. Through the International Electrotechnical Commission (IEC), technical experts from across the micro fuel cell industry have developed a comprehensive micro fuel cell safety standard (IEC/PAS 62282-6-1 Ed. 1) that these systems, and their fuel cartridges, will be required to meet prior to use. The IEC standard complements existing standards and regulatory requirements for consumer electronics products which will also apply to micro fuel cell systems.

Borohydride Based Fuel Cell Systems

Fuel cells work on the principle of electrochemical oxidation of a fuel to create electricity. The fuel can be hydrogen stored as a high pressure gas or absorbed in a metal hydride; fuel can be an organic fluid such as liquefied butane, methanol or formic acid; or fuel can be a salt—such as sodium or potassium borohydride, or a solution of these salts. Borohydrides have some distinct advantages over current battery technology which make them particularly well suited for portable electronic applications. As fuels, these materials offer high energy densities, portability, and stability.

For a viable and compelling fuel cell product, methods for providing a safe and affordable high energy density fuel are required. Micro fuel cells using borohydrides achieve this, and can generate electricity in two basic ways.

> **Direct Borohydride Fuel Cell (DBFC) System -** In this type of system a liquid (solution) formulation of borohydride is used directly as the fuel at the anode (negative terminal) of a micro fuel cell.
>
> **Indirect Borohydride Fuel Cell (IBFC) System -** In this type of system a solid or liquid (solution) formulation of borohydride is processed into hydrogen, which is then used as the fuel at the anode of a micro fuel cell.

In both cases air is required at the cathode (positive terminal) of the micro fuel cell. In this process oxygen from air reacts—via the fuel cell—either with the sodium or potassium borohydride itself (DBFC systems) or with the hydrogen released by the sodium or potassium borohydride (IBFC systems). The only product emitted into the air is water vapor; the byproduct from using borohydride fuel (a borate salt) is retained within the cartridge for subsequent disposal or recycling.

Both IBFC and DBFC systems require water, either as a separate liquid component or as the solvent for liquid sodium or potassium borohydride fuel formulations; in IBFC systems it is the combination of water with the sodium or potassium borohydride that releases the hydrogen.

Borohydrides as Fuel

Sodium and potassium borohydride are energy rich materials. Typically, sodium borohydride is the borohydride compound employed; potassium borohydride can also be used. The borohydride may be used as a pure dry solid or as a liquid or solid formulation including solvents, stabilizers, catalysts or other additives. The most common stabilizers used are strong bases such as sodium or potassium hydroxide, similar to the caustics used in several current battery technologies. The most common solvent used is water. Properly stabilized, sodium or potassium borohydride will typically lose less than 0.01% potency per year.

Most formulations of borohydride used as fuel, in solid and liquid form, are stabilized and are Class 8 Packing Group II materials - however, depending on the formulation, classification in Packing Group III is possible. Pure, dry sodium or potassium borohydride can also be utilized as fuel. These are Division 4.3, Packing Group I materials. However, some fuels may be mixtures of these materials with other solids, so that classification in Packing Group II or III of Division 4.3 is also possible.

These materials all have strong industrial and transport safety records and have been safely transported (including in portable tanks and tank wagons) and used in large quantities for over 50 years.

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